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EFFECTS OF RESPONSE CARDS ON STUDENT PARTICIPATION AND ACADEMIC ACHIEVEMENT: A SYSTEMATIC REPLICATION WITH INNER-CITY STUDENTS DURING WHOLE-CLASS SCIENCE INSTRUCTION

RALPH GARDNER, III, WILLIAM L. HEWARD, AND TERESA A. GROSSI
THE OHIO STATE UNIVERSITY

We evaluated the use of response cards during science instruction in a fifth-grade inner-city classroom. The experiment consisted of two methods of student participation—hand raising and write-on response cards—alternated in an ABAB design. During hand raising, the teacher called upon 1 student who had raised his or her hand in response to the teacher's question. During the response-card condition, each student was provided with a laminated board on which to write one- or two-word answers in response to each question asked by the teacher. Frequency of active student response was 14 times higher with response cards than with hand raising. All 22 students scored higher on next-day quizzes and on 2-week review tests that followed instruction with response cards than they did on quizzes and tests that covered facts and concepts taught with the hand-raising procedure.
DESCRIPTORS: academic behavior, classroom, education, teaching, response cards

A significant and growing body of behavioral and educational research is providing empirical support for John Dewey's (1916) contention that students learn by doing. Researchers using single-subject or group-comparison experimental methods have arrived at the same conclusion: Learning is enhanced when the frequency with which students actively respond during instruction is increased (e.g., Brophy, 1986; Delquadri, Greenwood, Stretton, & Hall, 1983; Greenwood, Delquadri, & Hall, 1984; Narayan, Heward, Gardner, Courson, & Omness, 1990; Pratton & Hales, 1986; Rosenshine, 1980; Rosenshine & Berliner, 1978; Sindelar, Bursuck, & Halle, 1986). Too often, however, classroom instructional activities allow students to be passive observers rather than active participants (Hall, Delquadri, Greenwood, & Thurston, 1982; Stanley & Greenwood, 1983). In fact, Graden, Thurlow, and Ysseldyke (1982) reported that the amount of time that students engage in actively responding occupied the smallest portion of time allocated for instruction.

Although Carta and Greenwood (1988) found that the quality and amount of instruction were the most important factors in improving the level of academic achievement by inner-city youth, these students may receive fewer opportunities to respond than their suburban counterparts do (Greenwood, Delquadri, Stanley, Terry, & Hall, 1986). Carta and Greenwood (1988) reported that deficits in academic behavior were independent of the students' levels of intelligence or socioeconomic status, but were dependent on how instruction was presented by the teacher. The variable most consistently related to increases in achievement was the extent to which students were academically engaged during instruction.

One of the most commonly used methods of whole-class instruction is lecture by the teacher (Brophy, 1988); however, this method has been found to be less effective than alternative strategies such as one-on-one tutoring (Bloom, 1984). One likely reason for the relative ineffectiveness of the lecture method is that students have few, if any,

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Correspondence and reprint requests may be sent to Ralph Gardner, III, Applied Behavior Analysis Program, The Ohio State University, 356 Arps Hall, 1945 N. High St., Columbus, Ohio 43210-1172.

opportunities to respond during the lesson. A common strategy used by teachers for generating student participation during whole-class instruction is to pose a question to the entire class and then call on one student to answer (Brophy & Evertson, 1976). This strategy often results in more frequent responses by high-achieving students and few or no responses by low-achieving students (Maheady, Mallette, Harper, & Sacca, 1991).

The use of response cards is one strategy that has shown promising initial results for increasing the frequency of active student response and subsequent academic achievement during large-group instruction (Narayan et al., 1990). Response cards are reusable signs or cards held up simultaneously by each student in the class to indicate his or her answer. Narayan et al. compared response cards and hand raising during whole-class social studies instruction in an inner-city fourth-grade classroom. During lessons in which response cards were used, individual students actively responded to 15 times more teacher-posed questions than during lessons in which students raised their hands. In addition, most students scored higher on daily quizzes following lessons with which response cards than on quizzes following lessons with hand raising.

The present study was designed as a systematic replication of the study by Narayan et al. (1990). We sought to extend the findings of the earlier study by (a) increasing the time between instruction and quiz to determine if the positive effects of response cards found in the earlier study could be extended to the next school day, (b) administering biweekly review tests to determine if any differential effects on achievement would be maintained, and (c) analyzing student performance on recall and recognition quiz and test questions.

The purposes of the study were to compare the effects of hand raising (HR) and response cards (RC) on (a) the frequency of active student responding during instruction, (b) the accuracy of student responses during instruction, (c) student performance on next-day quizzes and biweekly review tests, and (d) student performance on recall and recognition test questions. We also assessed which method of responding the students preferred.

METHOD

Subjects and Setting

The study took place in a fifth-grade classroom in an elementary school located in a low socioeconomic area of a large midwestern city. There were 13 boys and 11 girls in the class, ranging in age from 10 to 12 years. Because of frequent absences by 2 of the students, data are presented for only 22 students. Five students were selected for observation after consultation with their regular teacher, who indicated that they were representative of the range of participation and academic performance of the class. The 5 target students were divided into two groups of 3 and 2 students each, and the students in each group were observed on alternating trials. Students in each group sat at adjacent desks, enabling the observers to record the occurrence and accuracy of each student's response on the same trial.

The classroom was equipped with an overhead projector and screen. Students' desks and chairs were arranged in standard rows and columns, providing each student with an unobstructed view of the screen. The first author served as the teacher during the study. The third author served as the primary observer and sat to the right of the teacher, facing the students.

Dependent Variables

Five dependent variables were measured during the study: (a) teacher presentation rate, (b) number of student responses, (c) accuracy of student responses, (d) next-day quiz scores, and (e) biweekly review test scores. In addition, students' preferences and opinions concerning the two response methods used in the study were obtained in a two-question interview with each student at the conclusion of the study. Definitions and observation and measurement tactics for the first three dependent variables (a, b, and c above) were identical to those used by Narayan et al. (1990).

Next-day quiz scores. Beginning with Session 2, a 16-question quiz was administered at the start of each session. The quizzes tested students on science concepts and facts from the most recent

session. Each quiz consisted of eight recognition questions (multiple choice and true or false) and eight recall questions (requiring one- or two-word short answers or fill-in-the-blank).

Review tests. A 40-question review test was given every 2 weeks during the study. Each of the four review tests covered an equal amount of material selected randomly from each of the six to nine lessons conducted during the preceding 2 weeks. Each review test consisted of 20 recognition questions and 20 recall questions in an alternating sequence.

Interobserver Agreement

A second observer independently recorded the teacher's presentation of each instructional trial and the responses of the target students during at least two sessions of each of the four experimental phases. Procedures for obtaining and calculating interobserver agreement data were identical to those used by Narayan et al. (1990). During the two HR phases, interobserver agreement for hand raises across the 5 target students ranged from 82% to 100%. Agreement for number of student responses and accuracy of student responses during the HR phases across students ranged from 94% to 100% and from 92% to 100%, respectively. During the two RC phases, interobserver agreement for number of student responses ranged from 92% to 100%, and agreement for accuracy of student responses ranged from 82% to 100%. Interobserver agreement for next-day quiz scores across all 22 students ranged from 94% to 100% (M = 97%). Interobserver agreement on the two review tests scored by the second observer across all 22 students ranged from 95% to 100% (M = 98.4%).

Experimental Design and Procedure

An ABAB reversal design was used to analyze the effects of both experimental conditions. Each 45- to 55-min session consisted of three parts. Except for the first session, each session began with a quiz over the previous lesson. Each student was provided with an answer sheet and a yellow cover sheet to conceal his or her answers. To control for the students' wide range of reading abilities, the teacher read each question aloud twice while displaying the questions one at a time on the overhead projector. The teacher waited 10 s after reading a recall question for the second time and 5 s after reading a recognition question for the second time before displaying the next question. After all 16 questions had been presented, students were allowed to request the rereading of specific questions. Quiz scores counted toward the students' science grades.

During the second part of each session, the teacher used the overhead projector to present new science information to the students. To ensure treatment fidelity, the teacher followed a script for each lesson. The scripted lessons specified the content to be presented, questions to be asked, and all responses that would be scored correctly. The script also indicated the student response mode (HR or RC) to be used and ensured that the number of concepts presented remained constant across all sessions. Lessons on meteorology, climates, plants, and the solar system were developed for the study, using the fifth-grade text and activity book *Accent on Science* (Sund, Adams, & Hackett, 1982) and the *Silver Burdett Science Teacher Resource Book* (Mallinson, Mallinson, Smallwood, & Valentino, 1987). After each new fact or concept was presented, the teacher covered the information on the overhead projector and asked a question about the just-presented fact or concept. The students responded to all teacher-posed questions using the response method in use for that session. During the third and final part of each session, the teacher asked a series of review questions over the facts and concepts from that day's lesson.

Hand raising. On the school day preceding Session 1, the teacher used a geography lesson to provide the students with practice on the procedure for raising their hands and responding to questions. During HR sessions, the teacher waited 3 s after asking each question before calling upon an individual student whose hand was raised. As in the Narayan et al. (1990) study, a list of randomly ordered names of all students in the class was used

to determine which student was called upon after each question.

The teacher provided praise for each correct student response (e.g., "Excellent [student's name]! The *sun* is a star.") and corrective feedback for each incorrect answer (e.g., "No, the answer is the *sun*. The *sun* is a star."). Feedback statements were controlled so that all students heard the correct answer (e.g., *sun*) twice on every instructional trial.

Response cards. Presentation and question-asking procedures during the RC sessions were identical to those used during the HR sessions. Each student was provided with a white laminated particle board (22.9 cm by 30.5 cm) on which to write his or her responses to the teacher's questions with a dry-erase marker. On the school day prior to the first RC session, a 10-min practice session with response cards was conducted using a geography lesson. Procedures for using the response cards were the same as described by Narayan et al. (1990).

After visually scanning all of the response cards held up by the students on each trial, the teacher provided praise and/or corrective feedback. If everyone in the class had the right answer, the teacher addressed the feedback to the whole class (e.g., "Good class, water vapor in the atmosphere is a *gas*."). If some of the students' responses were incorrect, the teacher said, for example, "I see that many of you have *gas* as the answer. That is correct, water vapor in the air is in the form of a *gas*." If no student had the correct answer, the teacher said, for example, "I don't see any correct answers. The correct answer is *gas*. Water vapor in the atmosphere is a *gas*." As in the HR phases, the feedback procedure controlled the number of times (twice) students wrote and/or heard the correct answer to each question during instruction.

RESULTS

Teacher Presentation Rate

Mean teacher presentation rate during hand raising was 1.54 questions asked per minute, with a range of 1.00 to 2.16 across sessions. Mean teacher presentation rate when response cards were used was 0.99 questions per minute, ranging from 0.95 to 1.24 across sessions.

Student Responses During Instruction

The number of academic responses emitted by each of the 5 target students during each session is shown in Figure 1. Also shown is the number of times each student raised his or her hand during the two HR phases. During HR, the average number of times a target student raised his or her hand was 9.9, with a range of 0.7 to 21.3 across students. The number of academic responses by the target students during HR averaged 1.5 per session, with a range of 0 to 2.8. When response cards were used, each target student responded to teacher questions an average of 21.8 times per session (range, 5.8 to 28.3), a 14-fold increase.

Overall, the target students as a group orally responded 53 times to 1,103 teacher-posed questions during HR sessions, a participation level of 4% (see Table 1). During RC, these same students responded to 678, or 68%, of the 1,015 questions asked by the teacher. Data for several of the individual students are even more dramatic. For example, Student 5 made no responses during any of the 11 HR sessions for which he was present, but he answered teacher questions during 9 of the 12 RC sessions he attended, with a high of 13 responses during one session. Student 4 made only one response in each of three HR sessions and no responses in the other 10 HR sessions. In contrast, Student 4 averaged 12.7 responses per session when response cards were used.

Accuracy of student responses during instruction was high under both experimental methods, averaging 92% overall during HR sessions and 93% during RC sessions.

Next-Day Quiz Scores

The mean quiz scores for 21 of the 22 students during the first RC session were higher than the scores they obtained during the first HR session. Withdrawal of response cards during the second HR session resulted in a decrease in those students' mean quiz scores, and their quiz scores increased

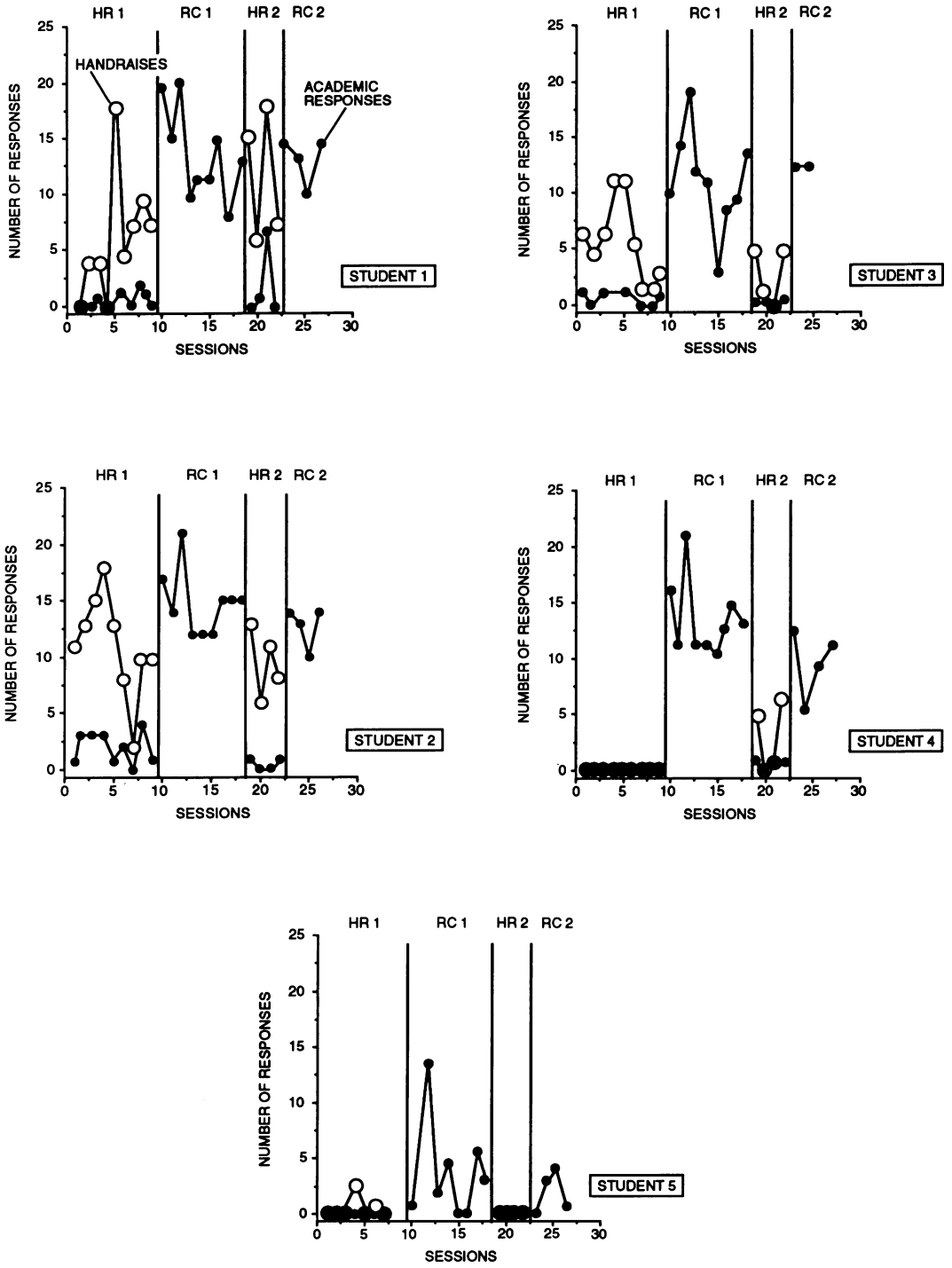

Figure 1. Number of academic responses and hand raises by Students 1 through 5 during science lessons in which students participated by hand raising (HR) or response cards (RC). Breaks in data paths indicate student absences.

Table 1
Student Participation During Both Experimental Conditions

	Hand Raising (13)[a]				Response cards (13)[a]			
Student	Responses	Response opportunities[b]	Participation[c] (%)	Accuracy (%)	Responses	Response opportunities[b]	Participation[c] (%)	Accuracy (%)
1	16	230	6.9	93.7	178	189	94.1	91.5
2	22	230	9.6	90.9	183	189	96.8	97.8
3	0	193	0.0	—	40	169	23.6	87.5
4	12	225	5.3	83.3	113	273	41.4	92.9
5	3	225	1.3	100.0	164	195	84.1	96.3
Group	53	1,103	4.0	91.9	678	1,015	68.0	93.2

[a] Numbers in parentheses indicate number of sessions in each condition.
[b] Differences in response opportunities across students are a function of absences.
[c] Percentage of response opportunities answered.

again during the second RC session. The mean quiz score for the 22 students increased from 59% during the first HR session to 70% during the first RC session, decreased to 51% when response cards were withdrawn, and increased again to 70% when response cards were reinstated. The overall mean score for the entire class during all HR sessions was 57% correct, compared to an overall mean score of 70% correct during RC sessions. (Results of individual students' next-day and review test scores can be obtained from the first author.)

Review Tests

Each student's accuracy on review test questions covering content initially instructed during RC was higher than his or her performance on test questions taught using HR. The class mean on review test items instructed during HR was 49% (range, 6% to 81%) across students. The mean percentage of RC-instructed items answered correctly on the review tests was 70%, (range, 32% to 95%).

Recall and Recognition Items

Next-day quizzes. The mean percentage of recall items correctly answered on next-day quizzes covering content presented during HR was 39%, compared to 62% on recall questions taught using RC. Overall accuracy on recognition items instructed during HR was 64%, compared to 78% for RC-instructed recognition items.

Review tests. The mean percentage correct recall test questions was 39% during HR, compared to 65% during RC. For recognition questions, the mean percentages were 60% for HR and 74% for RC.

Student Preferences

During the end-of-study interview, 16 of the 22 students said they preferred response cards over hand raising; 19 students said response cards helped them during instruction more than hand raising, and 20 students indicated that response cards helped them receive better grades than did hand raising.

DISCUSSION

This study replicated the findings of Narayan et al. (1990) in that response cards increased the frequency of active student response during whole-class instruction, improved students' scores on quizzes over the instructed content, and a majority of the students preferred response cards over hand raising. The results of this study also yielded new information on the use of response cards. First, positive effects of response cards were extended to science instruction, as compared to social studies in the Narayan et al. study. Although we agree with the current advocacy for more hands-on learning in science (Brandwein & Glass, 1991), there is a multitude of facts and definitions that students must master to be successful in science. Response

cards allow the teacher to teach facts and definitions more effectively in conjunction with hands-on experiences in which students apply those concepts. Second, the next-day quizzes offered a more significant measure of learning than did the same-day tests used by Narayan et al. Teachers typically do not test students until some time has passed after instruction. It was important to determine if the initial superior effects of response cards found by Narayan et al. could be sustained over time. We found that not only was improved achievement sustained when the students were quizzed the next day, but that improved performance on RC-instructed material was maintained on the biweekly review tests. These maintenance effects suggest that response cards might help students to be more successful in their school careers. The study also demonstrated a relationship between the method of student responding and the type of test question asked. Teachers were provided with information that allowed them to determine the most effective instructional strategy based on the type of test question the student is most likely to encounter.

As reported by Narayan et al. (1990), in the current study the teacher presented questions at a higher rate with the hand-raising procedure than when response cards were used. However, because only one student at a time could actively respond to each question during HR, a total of approximately 45 active instructional trials occurred during each session (1.5 questions presented × 30 min × 1 student). When response cards were used, an average of 660 potential instructional trials were presented each session (1 question presented × 30 min × 22 students). Using the participation level of the 5 target students during RC as representative of the whole class, it can be estimated that an average of 448 active learning trials actually took place during each 30-min lesson (660 × .68 × 100). Based on these data, if response cards were used instead of hand raising during a single 30-min lesson each school day, each student would make approximately 3,700 additional academic responses over the course of a 180-day school year.

In addition to increasing each student's opportunity to respond during instruction, response cards offered an important advantage for the teacher—visual access to each student's response on each learning trial. This direct and ongoing assessment of each student's performance enables the teacher to modify instruction as it is delivered.

Although the increases in quiz scores were relatively small and significant variability was observed within and across the HR and RC phases, a functional relation between use of response cards and improved quiz performance is suggested by the fact that the mean quiz score for all but 1 student increased from the first HR session to the first RC session, decreased during the second HR session, and improved again during the second RC session. These small increases and variability in quiz scores may have been influenced by the large number of questions (16 items) on each quiz, the difficulty of the subject matter, and/or the students' prior exposure to the various topics covered. In an effort to reduce the possibility of a ceiling effect on daily quiz scores, the number of quiz items was increased to 16 in the present study (from the 10 items used by Narayan et al., 1990). This change required more concepts to be presented each day, perhaps too many for the students to master in a single lesson. Despite these limitations, if letter grades had been assigned during HR based on the average quiz score earned by each student, only 2 students would have earned a "B" or better (80% correct and above), and 14 of the 22 students would have received a failing grade (below 60% correct). By contrast, 7 students earned a "B" or better during RC, and 5 students would have failed with RC.

Evidence that the effects of response cards were maintained is provided by the students' superior performance on RC-instructed items on the biweekly review tests. The mean performance for the class on review tests improved from a failing grade under HR to a "C" average during RC. Increasing students' ability to retain greater amounts of academic information over time has important implications in terms of curriculum-based assessment and, depending on the curriculum, on standardized achievement tests as well. Although these maintenance data are based on only four review tests,

the results are promising and suggest the importance of further research in this area.

Although accuracy of student responding to both recall and recognition questions improved with RC, the greater increase in accuracy on recall questions taught with RC suggests that the type of responses students make during instruction may be related to their ability to respond correctly to similar test questions later. Additional research is needed to determine if the write-on response cards used in this study, which required a recall response, may have positively influenced student performance on recall questions on the quizzes and review tests.

Most of the students preferred response cards over hand raising, stating that they were more fun to use. Students also felt that they learned more when response cards were used. In fact, during HR some students appeared frustrated at times when they were not called on: Some students stopped raising their hands at all, others put their heads down on their desks, and still others complained about not being called on. These behaviors were not observed during RC sessions. Subjective observation during this study showed that the students were less disruptive and stayed more on task when response cards were used than they were when the hand-raising method was used. These anecdotal results suggest that analyses of the effects of response cards on the social behavior of students during instruction are warranted. Finally, because experimenters implemented the response-card procedure in both this study and that of Narayan et al. (1990), future research must demonstrate that classroom teachers can use response cards effectively with their students.

REFERENCES

Bloom, B. S. (1984). The search for methods of group instruction as effective as one-to-one tutoring. *Educational Leadership, 41*(8), 4–17.

Brandwein, P. F., & Glass, L. W. (1991). A permanent agenda for science teachers. Part II: What is good science teaching? *The Science Teacher, 58*(4), 36–39.

Brophy, J. E. (1986). Teacher influences on student achievement. *American Psychologist, 41,* 1069–1077.

Brophy, J. E. (1988). Research linking teacher behavior to student achievement: Potential implications for instruction of chapter 1 students. *Educational Psychologist, 23,* 235–86.

Brophy, J. E., & Evertson, C. M. (1976). *Learning from teaching: A developmental approach.* Boston: Allyn & Bacon.

Carta, J. J., & Greenwood, C. R. (1988). Reducing academic risks in inner-city classrooms. *Youth Policy, 10,* 16–18.

Delquadri, J., Greenwood, C. R., Stretton, K., & Hall, R. V. (1983). The peer tutoring spelling game: A classroom procedure for increasing opportunity to respond and spelling performance. *Education and Treatment of Children, 6,* 225–239.

Dewey, J. (1916). *Democracy and education.* New York: Macmillan.

Graden, J., Thurlow, M. L., & Ysseldyke, J. E. (1982). *Academic engaged time and its relationship to learning: A review of the literature* (Monograph 17). Minneapolis, MN: University of Minnesota Institute for Research on Learning Disabilities.

Greenwood, C. R., Delquadri, J., & Hall, R. V. (1984). Opportunity to respond and student academic performance. In W. L. Heward, T. E. Heron, D. S. Hill, & J. Trap-Porter (Eds.), *Focus on behavior analysis in education* (pp. 58–88). Columbus, OH: Merrill.

Greenwood, C. R., Delquadri, J., Stanley, S., Terry, B., & Hall, R. V. (1986). Observational assessment of ecobehavioral interaction during academic instruction. In S. E. Newstead, S. H. Irvine, & P. D. Dan (Eds.), *Human assessment: Cognition and motivation* (pp. 319–40). Dordrecht, The Netherlands: Nijhoff Press.

Hall, R. V. , Delquadri, J., Greenwood, C. R., & Thurston, L. (1982). The importance of opportunity to respond in children's academic success. In E. B. Edgar, N. G. Haring, J. R. Jenkins, & C. G. Pios (Eds.), *Mentally handicapped children: Education and training* (pp. 107–140). Baltimore, MD: University Park Press.

Maheady, L., Mallette, B., Harper, G. F., & Sacca, K. (1991). Heads together: A peer-mediated option for improving the academic achievement of heterogeneous learning groups. *Remedial and Special Education, 12*(2), 25–33.

Mallinson, G. G., Mallinson, J. B., Smallwood, W. L., & Valentino, C. (1987). *Silver Burdett science: Teacher resource book.* Morristown, NJ: Silver Burdett Company.

Narayan, J. S., Heward, W. L., Gardner, R., III, Courson, F. H., & Omness, C. (1990). Using response cards to increase student participation in an elementary classroom. *Journal of Applied Behavior Analysis, 23,* 483–490.

Pratton, J., & Hales, L. W. (1986). The effects of active participation on student learning. *Journal of Educational Research, 79*(4), 210–215.

Rosenshine, B. (1980). How time is spent in elementary classrooms. In C. Denham & A. Lieberman (Eds.), *The appraisal of teaching: Concepts, findings, and implications* (pp. 28–56). Berkeley, CA: McCutchan.

Rosenshine, B., & Berliner, D. C. (1978). Academic en-

gaged time. *British Journal of Teacher Education, 4,* 3–16.

Sindelar, P. T., Bursuck, W. D., & Halle, J. W. (1986). The effects of two variations of teacher questioning on student performance. *Education and Treatment of Children, 20,* 195–207.

Stanley, S. O., & Greenwood, C. R. (1983). Assessing opportunity to respond in classroom environments through direct observations: How much opportunity to respond does the minority, disadvantaged student receive in school? *Exceptional Children, 49,* 370–373.

Sund, R. B., Adams, D. K., & Hackett, J. K. (1982). *Accent on science.* Columbus, OH: Merrill.

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